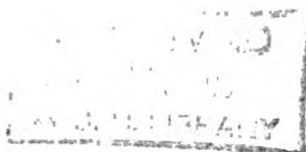


UNITED STATES
DEPARTMENT OF THE INTERIOR
HAROLD L. ICKES, SECRETARY

BUREAU OF MINES
JOHN W. FINCH, DIRECTOR

INFORMATION CIRCULAR

COAL-MINE EXPLOSIONS AND COAL- AND METAL-MINE FIRES IN THE
UNITED STATES DURING THE FISCAL YEAR ENDED
JUNE 30, 1937



BY

D. HARRINGTON AND W. J. FENE

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COAL-MINE EXPLOSIONS AND COAL- AND METAL-MINE FIRES IN THE
UNITED STATES DURING THE FISCAL YEAR ENDED
JUNE 30, 1937^{1/}

By D. Harrington^{2/} and W. J. Fene^{3/}

INTRODUCTION

The record of fatalities from mine explosions in the United States during the past 4 years has been the best in the history of the mining industry, despite the fact that the number of fatalities from this cause during the past fiscal year now is nearly double that of the previous year. During these 4 fiscal years, mine explosions have resulted in an average of 45.5 deaths per year, compared with an average of 153 deaths per year for the preceding 5 years; an average of 542 deaths per year for the 3 years 1907-1909, inclusive, and a yearly average of 265 deaths per year for the 20 years prior to 1929. Other types of mine accidents also have been reduced during this period, but not to the same degree or by as large a percentage as mine explosions. The fact that in this fiscal year ended June 30, 1937, electricity was responsible for 60 percent of the explosions and 85.5 percent of the fatalities resulting therefrom (see tables 3 and 4) is evidence that either mine operators are lax in providing proper electrical equipment or there is laxity in the upkeep and use of electricity in our mines and more particularly in our coal mines.

Several large coal-producing States that in the past have had numerous disastrous explosions have been free from such disasters for continuous periods of as long as 8 years. The bituminous mines of Pennsylvania, one of the largest coal-producing States, give a good example of what can be done to prevent explosions. This State, with its large number of operating mines, many with very definite hazards from gas or dust or both, has had only two major explosions (resulting in 16 fatalities) during the past 7 years; this is a decidedly good record compared with any similar period in the past and when it is considered that during this period about 750,000,000 tons of coal have been produced. Other good records are: Tennessee, without a single fatality from explosions during the past 9 years; Alabama, with 6 fatalities during the past 7 years; Illinois, with no explosions during the past 4 years; and

1/ The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 6986."

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Utah, with no explosions during the past 7 years. These are truly remarkable records compared with past records of these States, and an indication of what can be and should be done in other States, as the above mentioned States have coal-mining conditions as hazardous as to possible explosions as are found in any other State or States of the Union.

Mine explosions are the least excusable of all types of mine accidents, because it is now definitely known that the factors that contribute to explosions are subject to control; in fact, they are under control in hundreds of naturally hazardous coal mines in the United States. That this is true is shown by the fact that the mines with the most hazardous conditions as to gas or dust seldom have explosions or fires, and mine disasters almost invariably occur in properties that give off relatively little explosive gas and are looked upon as essentially non-gassy. In 19 of the 20 explosions that occurred during the past fiscal year and were investigated by Bureau of Mines' engineers, inadequate or interrupted ventilation was the primary cause of the gas accumulations the ignition of which prompted the explosions. Since the proper ventilation of a mine is the responsibility of the operating officials in charge of a mine, the responsibility for failure of ventilating is largely theirs, even though employees are often guilty of contributing negligence in one way or another. If ventilation of mines is adequate and properly controlled and maintained, the number of explosions will be negligible; this does not mean that coal dust can be ignored as a hazard in either well ventilated or poorly ventilated mines, since coal dust can be ignited even when no methane is present, regardless of the effectiveness or noneffectiveness of ventilation. Nevertheless, it is definitely true that effective ventilation is largely of employer responsibility; and if adequate ventilation was effective always and everywhere, coal-mine-explosion disasters would be largely a thing of the past.

SUMMARY OF MINE EXPLOSIONS, BY STATES AND CAUSES

Table 1 summarizes essential data on 20 explosions that occurred in eight States and resulted in 62 deaths during the fiscal year ended June 30, 1937. This table includes information on all explosions in coal mines in the United States that were brought to the attention of the Safety Division of the Bureau of Mines during the fiscal year, and it is believed to include every explosion in which life was lost or a considerable damage resulted. The 20 explosions during the year were five fewer than were investigated during the previous year; however, the number of deaths (62) was 24 more than in the previous year.

The States with the greatest number of deaths from explosions during the past fiscal year were West Virginia, 36; Pennsylvania, 14 (5 were in anthracite mines); Arkansas, 5; Oklahoma, 3; Virginia, 2; and Colorado and Washington, 1 each. West Virginia had the greatest number of explosions, 8; Pennsylvania had 5 (4 in anthracite mines); Washington had 2; and Arkansas, Colorado, Oklahoma, Tennessee, and Virginia had 1 each.

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TABLE 1. - Summary of explosions, by States and causes, fiscal year 1937

State	Fatalities, by ignition causes										
	Lighting used		Electricity		Open lights or smoking		Explosives		Miscellaneous or unknown		Total
	Open	Closed	Unknown	Deaths	Igni- tions	Deaths	Igni- tions	Deaths	Igni- tions	Deaths	
Arkansas.....	-	1	-	5	1	-	-	-	-	5	1
Colorado.....	-	-	1	1	1	-	-	-	-	1	1
Oklahoma.....	-	1	-	-	-	3	1	-	-	3	1
Pennsylvania ^{1/}	2	2	1	9	2	0	2	5	1	14	5
Tennessee.....	1	-	-	-	-	0	1	-	-	0	1
Virginia.....	-	1	-	2	1	-	-	-	-	2	1
Washington.....	1	1	-	1	1	0	1	-	-	1	2
West Virginia.	-	6	2	35	6	-	-	1	1	36	8
Total, fiscal year 1937...	4	12	4	53	12	3	5	0	2	62	20
Total, fiscal year 1936...	15	9	1	20	5	10	17	4	2	38	25
Total, fiscal year 1935...	6	17	-	29	10	6	9	3	2	54	23
Total, fiscal year 1934...	9	14	3	21	10	2	9	3	4	28	26
Total, fiscal year 1933...	7	14	1	25	8	63	8	29	2	122	22
Total, fiscal year 1932...	15	15	4	11	10	33	15	42	3	87	33
Total, fiscal year 1931...	12	15	-	143	9	56	11	18	-	217	26
Total, fiscal year 1930...	8	25	1	154	18	21	8	24	2	199	34
Total, fiscal year 1929...	18	19	1	93	18	14	11	26	1	139	38

^{1/} Four of these five explosions were in anthracite mines.

Five major explosions, resulting in 47 deaths, occurred during the fiscal year 1937 (one mine accounted for two of these, both of electrical origin). (A major explosion is one in which five or more men are killed.) During the fiscal year 1936 there were two major explosions, which resulted in 17 deaths. Eight of the 20 explosions that occurred during the past fiscal year did not result in fatalities.

Fifty-three persons were killed during the past fiscal year in explosions initiated by electricity, compared with 20 deaths the previous year and an average of 21 deaths per year for the preceding 5 years. Deaths from explosions due to electricity increased substantially during the past year over any year of the previous five; however, this is a substantial decrease from the average of 130 deaths per year from explosions of electrical origin during the period 1929-1931, inclusive, the number being 143 in 1931 and 154 in 1930. There were 12 electrical ignitions during 1937, compared with 5 such ignitions the previous year and an average of 13.5 for the previous 8 years. The greatest number of electrical ignitions (six) occurred in West Virginia and resulted in 35 fatalities; Pennsylvania had two, with 9 fatalities; and Arkansas, Colorado, Virginia, and Washington had one each, with a total of 9 deaths.

During the fiscal year 1937, five ignitions were caused by open lights or smoking (two of which were in anthracite mines), compared with 17 during 1936 and an average of 11 during the previous 8 years. Deaths due to explosions caused by open lights or smoking last year numbered 3, compared with an average of 25.5 during the previous 8 years. Ignitions caused by open lights or smoking were distributed as follows: Pennsylvania 2, with no deaths; Oklahoma 1, with 3 deaths; Tennessee and Washington 1 each, with no deaths. Fewer deaths have resulted from explosions caused by open lights and smoking during the past 4 years than in any other 4-year period in the history of mining in the United States. This decrease has been brought about chiefly by the elimination of open lights in many mines, both gassy and so-called nongassy, and by the materially increased use of electric cap lamps, not only because of their much greater safety than open lights in avoiding initiation of explosions and fires but also because of their much more efficient and dependable light.

Only one explosion during the past fiscal year was caused by explosives (and it resulted in no loss of life), compared with an average of 4.3 explosions and 18.5 deaths during the previous 8 fiscal years. This is a new low record and is believed to be due to the wider use of permissible explosives as well as to the extension of education in safe practices in the use of explosives.

Two explosions from miscellaneous or unknown causes resulted in six deaths. One of these was in a Pennsylvania anthracite mine and one in West Virginia; the latter is reported to have been caused by ignition of gas by a frictional spark from a blow of a hammer on a bolt.

RECORD OF MINE EXPLOSIONS, BY STATES

Table 2 shows the record of explosions by States during the past 9 fiscal years. During the 9-year period, 247 ignitions caused 956 deaths, an average of 27.44 ignitions and 106.22 deaths per year; hence, the number of ignitions (20) and deaths (62) during the past year was much less than the average for the 9 years, and 7 fewer ignitions and 44 fewer deaths were caused by explosions last year than the average for the 9-year period. For this period, Pennsylvania heads the list in total number of known ignitions (76) with the largest number of deaths (187); West Virginia is next on the list with 47 ignitions and 142 deaths; and Oklahoma, with only 12 ignitions, had the next largest number of deaths (126) and had no known ignitions during 3 years of this period; it would appear that inadequate provision is made in Oklahoma mines not only as to ventilation and ignition agencies, but also that rock dusting and similar practices to prevent spread of explosions are anything but adequate. It is of interest to note that during this 9-year period Arkansas, Kansas, Maryland, and Wyoming had one ignition each, with a total of 11 deaths for the four States; Tennessee had 4 ignitions without a fatality in the 9 years; Kansas has not had a known ignition for the past 8 years, and Utah for the past 7 years; Arkansas was relatively free of ignitions for the 9 years until a major disaster occurred during the past fiscal year; and Maryland has had a very good record, with but 1 ignition and 1 fatality during the period in question.

The average number of deaths per ignition during the past 9 fiscal years is 3.87, with a range for the various States from none to 10.67 deaths per ignition. States with the most deaths per ignition during the past 9 years are Ohio (10.67), Oklahoma (10.50), and Virginia (7.80), in which States relatively little attention is given to rock-dusting or to the use of closed lights and to precautions with electrical equipment. The following coal-mining States and territories are not listed in table 2, as they are not known to have had an explosion during the past 9 fiscal years: Alaska, Iowa, Michigan, Missouri, Montana, North Dakota, and Texas.

CAUSES OF EXPLOSIONS

Table 3 gives data on causes of explosions in the United States during the past 9 years as reported to the Safety Division of the Bureau of Mines by its field investigators. In all, 247 explosions have been studied during the 9-year period, an average of 27.4 explosions per year. There were 20 explosions during the past fiscal year, 5 fewer than during the previous year and 7.4 fewer than the average for the 9 years. Electricity accounted for 100 (40.5 percent), and open lights or smoking for 93 (37.6 percent), or a combined total of 78.1 percent of the explosions during this period were started by ignitions due to electricity, open lights, and smoking.

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TABLE 2. -- Record of explosions, by States, during last nine fiscal years

State	1928-29		1929-30		1930-31		1931-32		1932-33		1933-34		1934-35		1935-36		1936-37		Total, 9 years		Average per year		Average deaths per ig- nition
	Deaths	Igni- tions	Deaths	Igni- tions	Deaths	Igni- tions	Deaths	Igni- tions	Deaths	Igni- tions	Deaths	Igni- tions	Deaths	Igni- tions	Deaths	Igni- tions	Deaths	Igni- tions	Deaths	Igni- tions	Deaths	Igni- tions	
Alabama	13	7	8	4	-	2	4	5	-	-	2	2	-	-	1	-	-	27	22	3.00	2.44	1.23	
Arkansas	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	5	1	.55	.11	5.00	
California	-	1	7	2	12	1	-	1	-	-	-	-	-	-	-	-	19	6	2.11	.64	3.17		
Colorado	-	-	-	1	-	-	-	3	1	1	-	-	-	-	2	1	1	18	8	2.00	.88	2.25	
Illinois	-	3	10	2	2	1	3	3	54	1	-	-	-	-	-	-	69	10	7.66	1.11	6.90		
Indiana	-	-	-	-	28	1	-	-	4	2	-	-	-	-	3	-	34	6	4.00	.66	5.67		
Kansas	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	.22	.11	2.00		
Kentucky	11	3	16	1	-	-	3	1	26	2	1	1	1	1	1	-	66	10	7.33	1.11	6.60		
Maryland	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	1	1	.11	.11	1.00		
New Mexico	-	-	-	-	8	3	-	-	14	1	-	-	-	-	-	-	22	4	2.44	.44	5.50		
Ohio	3	3	1	2	88	3	-	-	-	-	-	-	-	-	1	-	96	9	10.66	1.00	10.67		
Oklahoma	1	1	71	4	45	2	-	-	3	2	-	-	3	-	-	-	126	12	14.00	1.33	10.50		
Pennsylvania	70	9	16	8	23	7	7	6	9	6	16	14	24	11	10	5	187	76	20.77	8.44	2.50		
Tennessee	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	1	-	4	-	-	.44	-	
Utah	1	2	30	3	-	-	-	-	-	-	-	-	-	-	-	-	31	5	3.44	.55	6.20		
Virginia	2	1	-	-	-	-	54	3	-	-	-	3	18	2	-	1	78	10	8.60	1.11	7.80		
Washington	-	-	17	2	-	2	-	-	-	1	-	2	-	-	4	2	20	13	2.22	1.44	1.54		
West Virginia	36	7	23	5	11	4	11	7	9	5	8	4	5	4	3	8	142	47	15.77	5.22	3.02		
Wyoming	-	-	-	-	-	-	-	-	-	-	-	-	3	1	-	-	3	1	.33	.11	3.00		
Total	139	38	199	34	217	26	87	33	122	22	28	26	54	22	38	25	62	247	956	106.22	27.44	3.87	

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The number of explosions of electrical origin during the past year (12) is slightly more than the average of the preceding 8 years (11), while the number caused by open lights or smoking (5) has decreased materially from the average of 11 from those causes during the previous 8 years. This indicates rather definitely that the rapid introduction of the use of electric cap lamps has brought about much greater safety as regards ignition of gas by lighting, but the increase in electrical ignitions may (probably does) indicate that with introduction of the electric cap lamps there are relaxations in ventilation, with the result that some, at least, of the ignitions formerly caused by open lights are now caused by carelessness of various kinds with ventilation and electricity.

Table 3 shows that the number of explosions caused by explosives has decreased gradually during the past 9 years, only one having occurred during each of the last two fiscal years. Unquestionably, there have been numerous explosions caused by explosives during the past 9 years besides the 36 listed, as many explosions originating from blasting, which do not result in death or serious property damage, may not come to the attention of the Safety Division personnel; it is also possible that some explosions due to explosives and with single deaths may escape the attention of Bureau of Mines investigators. The favorable reduction in explosions caused by explosives may be attributed chiefly to the increased use of permissible explosives, to safe practices in the handling of explosives, to improved ventilation, and to more intensive supervision now being given some phases of coal-mining practice.

Of the two explosions listed under unknown or miscellaneous causes, one is reported to have been caused by a spark from a blow of a hammer on a bolt, although this is problematical and debatable; the cause of the other explosion under this classification was unknown.

EXPLOSION FATALITIES, BY CAUSES

Table 4 compares explosion fatalities by causes and shows that during the past 9 years 946 fatalities have resulted from explosions in mines of the United States, an average of 105 per year. The record for the past 4 years, an average of 45.5 per year, is by far the best since records have been available. The reduction in fatalities from explosions during the past 4 years has not been brought about through a marked decrease in the number of explosions, but rather by a decrease in their severity. The average number of deaths per explosion during the first 5 years of this 9-year period amounted to 5.0, while the average during the last 4 years has been 1.9. The reduction in the severity of explosions has been brought about largely by the use of rock dust to prevent widespread explosions and by the use of water on cutter bars of mining machines to prevent coal dust from getting into suspension in the air.

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TABLE 3. - Comparison of explosions by ignition causes,
fiscal years 1929-37, inclusive

Years	Ignition by electricity		Ignition by open lights or smoking		Ignition by explosives		Ignition due to unknown or miscellaneous causes		Total	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
1928-29	18	47.4	11	29.0	8	21.0	1	2.6	38	100
1929-30	18	52.9	8	23.5	6	17.6	2	6.0	34	100
1930-31	9	34.6	11	42.3	6	23.1	-	-	26	100
1931-32	10	30.3	15	45.5	5	15.1	3	9.1	33	100
1932-33	8	36.4	8	36.4	4	18.1	2	9.1	22	100
1933-34	10	38.5	9	34.6	3	11.5	4	15.4	26	100
1934-35	10	43.5	9	39.1	2	8.7	2	8.7	23	100
1935-36	5	20.0	17	68.0	1	4.0	2	8.0	25	100
1936-37	12	60.0	5	25.0	1	5.0	2	10.0	20	100
Total, 9 years	100	40.5	93	37.6	36	14.6	18	7.3	247	100
Average per year	11.1	40.5	10.2	37.6	4.0	14.6	2.0	7.3	27.4	100

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Explosions of electrical origin were responsible for 58 percent of the deaths from explosions during the past 9 years; during the past fiscal year, 85.5 percent of the fatalities from explosions were of electrical origin, which is considerably more than the average. The fact that electricity continues to lead the list of causes of explosions in mines is evidence of the continuance of lack of respect for the hazard of electric arcs in the presence of gas and dust. The fact that during the past fiscal year 53 persons were killed in explosions of electrical origin, against an average of 21 deaths annually from this cause during the 5 previous years, is decidedly ominous, and our coal-mining people would do well to take steps to guard against the electrical hazard. The rapid increase in the introduction of electrical equipment underground during the past few years is likely to result in heavy increase in explosions of electrical origin unless greater attention is given to precautionary measures in the use of such equipment. In view of this obvious fact, it would appear that no electrical equipment except that known to have all available safeguards should be allowed in mines, and this would automatically restrict the use of electrical equipment in mines to that given the rigid safety tests of the Bureau of Mines.

Open lights and smoking caused explosions that resulted in 208 deaths and 22 percent of all fatalities due to explosions during the past 9 fiscal years. Three deaths, accounting for 4.8 percent of all fatalities for the year, were due to explosions during the past fiscal year. A substantial decrease has been shown in the number of fatalities due to explosions caused by open lights and smoking during the past 4 years, when an average of 5.2 deaths per year is recorded, compared with an average of 37.4 deaths per year during the preceding 5 years. Four of the five explosions caused by open lights during the past year resulted in no deaths. At the mine where the explosion caused three deaths, closed lights are used; but a carbide light, used to light shot fuses, ignited gas during an attempt to light a fuse; it is difficult to understand the reasoning of an operator who will install electric cap lamps and then permit the use of carbide lights to light fuse or to allow smoking or use of open types of electrical equipment at the face region in a mine that is definitely known to be gassy or even one in which gas is known to occur occasionally or in certain places or under certain conditions.

During the past 9 years, 148 deaths (15.7 percent of all deaths due to explosions during this period) resulted from explosions caused by the misuse of explosives. No deaths from explosions resulting from the misuse of explosives are known to have occurred during the past fiscal year, and there was a very marked reduction during the previous 4 years, with a total of 9 deaths, compared with a yearly average of 28 deaths during the first 5 years of the period. Unquestionably, explosives practices are being improved greatly, especially in so far as the initiation of explosions is concerned; however, much remains to be done before it can be stated truthfully that explosives practice in mining (coal or metal) is anything near being safe.

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TABLE 4. - Comparison of explosion fatalities by ignition causes,
fiscal years 1929-37, inclusive

Years	Electricity		Open lights or smoking		Explosives		Unknown or mis- cellaneous causes		Total	
	Number killed	Percent	Number killed	Percent	Number killed	Percent	Number killed	Percent	Number killed	Percent
1928-29	93	66.9	14	10.1	26	18.7	6	4.3	139	100
1929-30	154	77.4	21	10.5	24	12.1	-	-	199	100
1930-31	143	65.9	56	25.8	18	8.3	-	-	217	100
1931-32	11	12.7	33	37.9	42	48.3	1	1.1	87	100
1932-33	25	20.5	63	51.6	29	23.8	5	4.1	122	100
1933-34	21	75.0	2	7.1	2	7.1	3	10.8	28	100
1934-35	29	53.7	6	11.1	3	5.6	16	29.6	54	100
1935-36	20	52.6	10	26.3	4	10.55	4	10.55	38	100
1936-37	53	85.5	3	4.8	0	-	6	9.7	62	100
Total, 9 years	549	58.0	208	22.0	148	15.7	41	4.3	946	100
Average, per year	61.0	58.0	23.1	22.0	16.4	15.7	4.5	4.3	105	100

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During the past 9 years, 41 persons were killed in mines in the United States in 18 explosions due to miscellaneous causes or causes not ascertained by the Bureau of Mines. During the past year one explosion in an anthracite mine, causing 5 deaths, was classified as being of unknown origin, and one in a bituminous mine was classified as miscellaneous. It is often difficult, if not entirely impossible, to determine definitely the cause of an explosion, because usually the persons implicated in the origin are killed, and in many cases surrounding conditions are changed to such an extent or are of such nature that available evidence cannot reveal the cause.

ELECTRICAL CAUSES OF EXPLOSIONS

Table 5 gives a "break-down" of data available to the Bureau of Mines relating to details of the causes of explosions of electrical origin in the United States during the past 9 fiscal years. During the period there were 100 ignitions of electrical origin, with 12 ignitions causing 53 deaths during the past fiscal year. The greatest sources of electrical ignitions in coal mines are trolley or cable-reel locomotives and nonpermissible mining machines, which, jointly, were responsible for approximately half of the electrical ignitions during the 9-year period and for two-thirds of the explosions during the past fiscal year. The trolley and cable-reel locomotive and the nonpermissible electrically operated mining machine (undercutter, overcutter, or shearer) are menaces that should not be allowed to continue their inroads on the lives of underground workers. In addition to the explosion hazard, these locomotives and their wires and, possibly to a less extent, the mining machines cause dozens of deaths to mine workers annually through contact with the electrical current. Unquestionably, the trolley system should be superseded by storage-battery locomotives or possibly Diesel engines or some other relatively safe system, even if this is to be done with a slight sacrifice of efficiency; and there is reason to believe that efficiency, if predicated on all of the surrounding facts and factors, will be raised rather than lowered; and certainly it is anything but logical to continue the rapid increases in use of electrical machinery at the gassy, dusty face region of mines without requiring that all such machinery (including mining machines) should be of permissible types and that they be kept in permissible condition and used in a permissible safe manner.

The practice of "nipping", while fairly widespread, is hazardous in the extreme and should be prohibited in all mines; and there is good reason to believe that not only safety but efficiency would be served if mining machines were equipped with storage-battery equipment not only for operation in cutting but also to propel the machines safely and expeditiously from place to place and thus remove the hazards and delays due to nipping and eliminate the dangers, delays, and other wasteful features of the trailing cable and power lines.

During the past fiscal year trolley locomotives were responsible for five explosions, nonpermissible mining machines for three explosions and cable nips, faulty wiring, trolley wire, and signal wire were responsible for one explosion each.

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TABLE 5. - Electrical causes of explosions, fiscal years 1929 to 1937, inclusive

Cause	Number of electrical ignitions, by fiscal years										Total, nine years	Number killed	Number injured	
	1929	1930	1931	1932	1933	1934	1935	1936	1937					
Trolley or cable-reel locomotive	1/5	5	1	1	4	5	3	1	5	1/29	2	25	-	1
Nonpermissible mining machine...	2/5	5	3	3	1	-	2	1	3	2/22	1	7	1	5
Nonpermissible electric motor...	4	3	-	-	-	-	2	-	-	9	-	-	-	-
Nonpermissible shot-firing bat- tery or circuit.....	-	3/2	3/3	1	-	1	-	-	-	2	-	-	-	-
Cable nips or cable blow-outs...	-	2	-	-	-	1	-	-	1	4	-	18	-	-
Nonpermissible electric drill...	-	-	-	2	-	1	2	-	-	5	-	-	-	-
Nonpermissible storage-battery locomotive.....	1	1	2	-	-	-	-	-	-	4	-	-	-	-
Nonpermissible electric hoist...	-	-	-	-	1	-	-	-	-	1	-	-	-	-
Faulty wiring.....	2	2	-	-	-	-	-	1	1	6	-	1	-	-
Trolley wire.....	1	-	2	1	-	-	-	1	-	5	8	-	-	-
Electric arc.....	2	-	1	2	1	2	1	4/1	1	11	9	2	1	-
Signal wire.....	-	-	-	-	1	1	-	-	1	2	-	-	-	1
Total.....	18	18	9	10	8	11	10	5	12	100	20	53	1	7

1/ One not included in total; may have been from open light.

2/ One not included in total; may have been from smoking.

3/ Not included in total; may have been from overcharged shot.

4/ Included, but may have been from smoking.

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In most electrical ignitions that have occurred during the past 9 years there has been evidence of carelessness in ventilation through doors left open on main or important haulage entries or line brattices in poor condition or not near enough to the face. Other factors concerned in these electrical ignitions were (1) failure to test for gas before going into working place with mining machine or electric drill; (2) use of electrical equipment too soon after mine fan had been started after a period of shut-down; and (3) use of haulageways as return airways, this practice always being hazardous in the extreme, especially where electricity is used, whether in gassy or so-called nongassy mines.

COMPARISON OF LIGHTING IN MINES WHERE EXPLOSIONS OCCURRED

Table 6 gives data as to methods of lighting in mines where explosions have occurred during the past 9 fiscal years, and it is observed that of the 249 explosions listed 95, or 38.2 percent, were in open-light mines; that 142, or 57 percent, were in closed-light mines; and that 12, or 4.8 percent, were in mines in which the lighting practice was unknown. During the past fiscal year five (25 percent) of the explosions occurred in open-light mines, a considerable reduction compared with the average of the preceding 8 years (11+). The fact that during the past fiscal year 70 percent of the explosions occurred in closed-light mines and that during the past 9 years 57 percent of all explosions occurred in mines using closed lights may be interpreted in several ways, and probably the most nearly correct explanation is that in most States gassy mines are required to use closed lights; therefore, it is most likely that closed lights are used in mines where the explosion hazard is at a maximum. The fact that most of the explosions do occur in mines where closed lights are used, added to the fact that, so far as known, there isn't even one case of an explosion started by an electric cap lamp, indicates carelessness in connection with other explosion-prevention methods and practices in at least some closed-light mines. Among these evidences of carelessness one of the most evident is a gross lack of appreciation of the hazards of inadequate ventilation, with attendant lack of appreciation of the numerous hazards of electricity as evidenced by use of nonpermissible or open types of electrical equipment and installations in haulage, cutting, loading, drilling, and other operations performed at the most gassy or dusty places in mines - the face region and the haulage roads. Also, explosions are initiated in closed-light mines by smokers' matches; by the use of fuse in putting off blasts; by nonpermissible explosives such as pellet powder or granular black blasting powder; by the very dangerous method of nipping of mining machines, trolley, and other locomotives; by open types of electrical switches, etc., and there have been numerous cases in which the use (or perhaps it should be termed the misuse) of the flame safety lamp has precipitated gas ignitions in closed-light mines. There is good reason to believe that in many mines in which closed lights are adopted, undue dependence is placed thereafter on the lamps, with more or less flagrant neglect of ventilation and other precautionary measures. The present-day types of electric cap lamps are safe and dependable and, in addition, give a vastly greater amount of light than any other portable miners light yet

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TABLE 6. - Comparison of lighting in mines where explosions occurred,
fiscal years 1929-37, inclusive

Year	Open lights		Closed lights		Lighting unknown		Total	
	Number of explosions	Percent	Number of explosions	Percent	Number of explosions	Percent	Number of explosions	Percent
1928-29.....	13	47.4	19	50.0	1	2.6	33	100
1929-30.....	8	23.5	25	23.5	1	3.0	34	100
1930-31.....	12	44.4	15	55.6	-	-	1/27	100
1931-32.....	15	44.1	15	44.1	4	11.8	1/34	100
1932-33.....	7	31.8	14	63.6	1	4.6	22	100
1933-34.....	9	34.6	14	53.9	3	11.5	26	100
1934-35.....	6	26.1	17	73.9	-	-	23	100
1935-36.....	15	60.0	9	36.0	1	4.0	25	100
1936-37.....	5	25.0	14	70.0	1	5.0	20	100
Total, 9 years	95	38.2	142	57.0	12	4.3	2/249	100

1/ One mine had mixed (open as well as closed) lighting.

2/ Two mines had mixed (open as well as closed) lighting.

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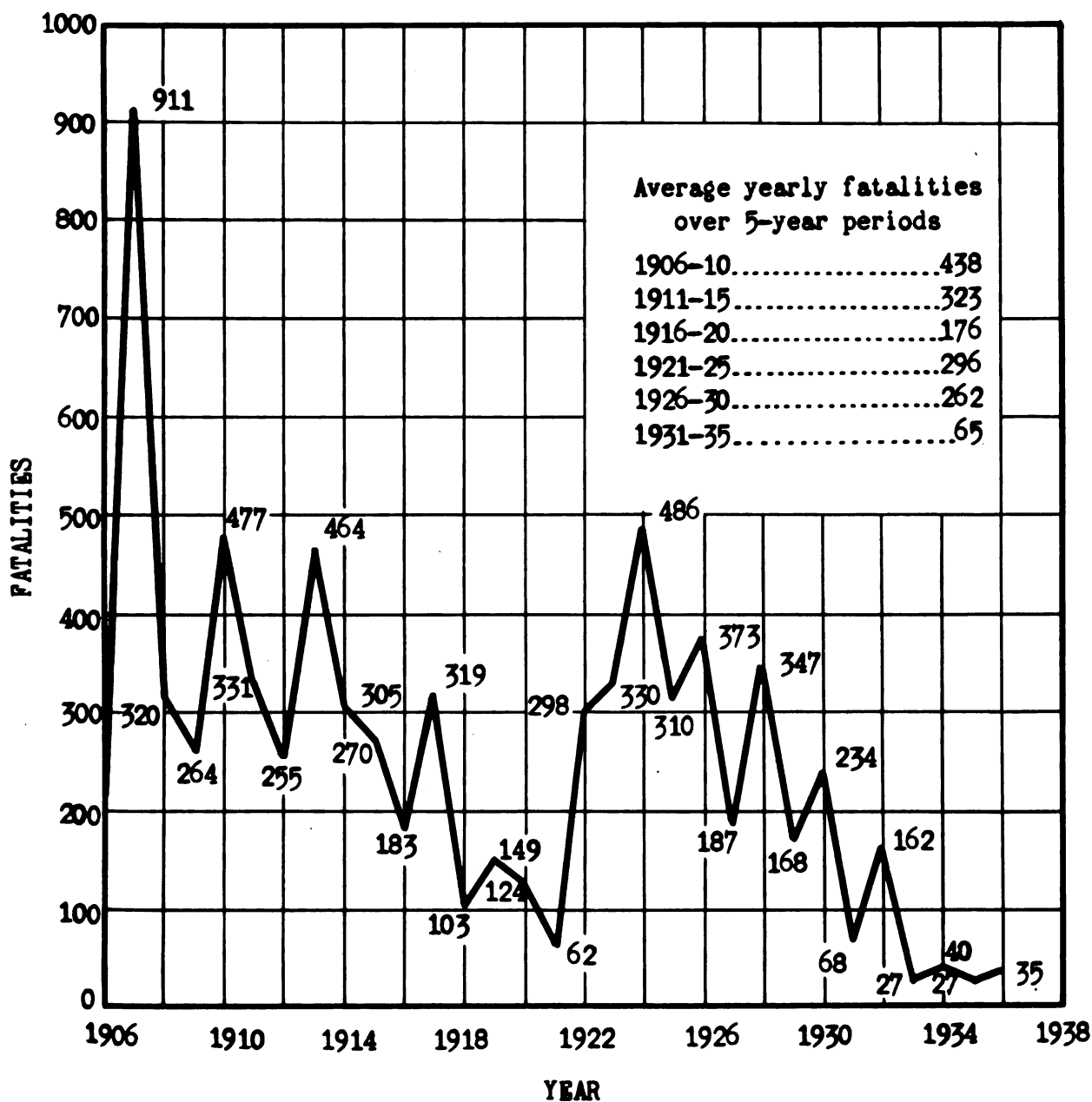


Figure 1.- Fatalities from gas and coal-dust explosions in bituminous-coal mines, 1906 to 1936, inclusive.

devised; they do not, however, constitute a panacea for all of the hazards incidental to mining and should not be required to be.

EXPLOSIONS IN BITUMINOUS COAL MINES

The graph shows the fatalities resulting from gas and coal-dust explosions in bituminous coal mines in the United States during the calendar years 1906 to 1936, inclusive. The trend was downward from 1907 to 1921, with a marked rise from 1921 to 1924 and a definite, fairly steady, downward trend from that year to date. It is rather significant that every alternate year since 1924 has shown an increase in the number killed over the preceding year, although the general trend has been downward. A possible explanation is that a year with relatively low explosion fatality record probably causes a certain amount of relaxation of accident-prevention effort during the following year, and conversely, one or more explosion disasters tends to act as a spur toward the taking of precautionary measures.

The tabulation on the graph giving average yearly fatalities from bituminous coal-mine gas and dust explosions over 5-year periods from 1906-10 to 1931-35 is illuminating, showing, as it does, a heavy and fairly steady decrease in annual fatalities from 438 for the 5-year period 1906-10 to 65 for the 5-year period 1931-35, a decrease of 85.2 percent. The significance of this is seen from the fact that if the rate of explosion fatalities for the 5-year period 1906-10 (438 per year) had continued through 1935, 13,140 lives would have been lost from this cause instead of 7,800 (the approximate number actually lost); if the rate of occurrence of such accidents in the 5-year period 1931-35 (65 per year) had been in effect from 1906 to the end of 1935, the total would have been only 1,950 instead of the approximately 7,800 that actually were killed. Additional significance attaches to the fact that during the past four calendar years, 1933-36, inclusive (see the graph), the fatalities from coal-mine disasters in the United States averaged but 32 per year; and if this is compared with the average of 438 annually for the 5-year period 1906-10, inclusive, the reduction is 92.7 percent; or, in other words, where 100 persons were being killed in coal-mine disasters in the period 1906-10, inclusive, only 7.3 have been killed so in the past four calendar years. These figures give a startling picture of the progress that has been made in the reduction of the coal-mine disasters in the United States since the Bureau of Mines was commissioned by Congress in 1910 to try to reduce the annual death toll from that cause.

MINE FIRES

Because of the highly combustible nature of coal, timber, and other materials found or used in mines, the potential hazard of a fire is always present in every mine, coal or metal, and this is true even when the mine is classed as damp or even wet. Some coals and other materials used in mines ignite spontaneously under certain conditions, which creates a very serious situation where such coals are being mined or such materials are used; but the most prolific causes of ignition of mine fires are

electricity, explosives, and open lights. Although fire hazards are always present, the mines of the United States have been fortunate during the past decade in that they have not experienced a fire that caused large loss of life; however, a number of fires have involved considerable property damage, and during the past few years mine fires have been causing more than usual loss of life, especially in coal mines, where the victims are far more likely to be killed by breathing the poisonous gases than by contact with the fire or its heat. Although much can be done to prevent mine fires, some companies continue to employ methods or equipment that have caused and very likely will continue to cause fires in their mines, such as the use of black powder or fuse; slipshod methods of installing, using, and maintaining electrical equipment; continued use of open lights; the permitting of smoking; and other loose, unsafe, or out-of-date mining equipment, methods, and practices.

During the past fiscal year 21 fires were called to the attention of the Bureau of Mines; scores of other fires were detected and extinguished promptly without much damage or were handled quietly and in some cases more or less secretly by the mine involved, so that their occurrence was not made known to the Bureau of Mines or to the general public.

Table 7 shows that during the past fiscal year California, Kentucky, and Pennsylvania each reported three fires; Indiana and New Mexico each reported two fires; and Alabama, Arkansas, Idaho, Illinois, Missouri, Virginia, Washington, and Wyoming each reported one fire. Of the 21 fires, 5 were in metal mines and one in a construction tunnel. Eleven fatalities resulted from these 21 fires; in one instance nine men were overcome by carbon monoxide while attempting to seal off a fire, and in another two men were overcome underground from a fire in the tipple. Electricity caused five of the fires and explosives three. Of the 13 fires listed under miscellaneous causes; 3 were probably caused by spontaneous combustion; 1 was probably of incendiary origin; 6 were of unknown origin; 2 were outcrop fires of long standing; and 1, in a metal mine, is thought to have started from a discarded lighted cigarette. The three fires charged to explosives were caused by flame from black powder in pellet form igniting the coal. The total number of fires (23) reported to the Bureau of Mines during the fiscal year 1937 about equals the average for the preceding 7 years; however, the deaths caused by fires during the past year (11) were more than the average for this period (7+). In at least one instance the loss of life was unnecessary, as the men who were killed apparently took no precautionary measures to test for or guard against poisonous gases.

TABLE 7. - Mine fires, by State, fiscal year 1937
and 1930-37, inclusive

State	Lighting used		Fatalities by ignition causes									
			Electricity		Open lights		Explosives		Miscellaneous		Total	
	Open	Closed	Deaths	Igni- tions	Deaths	Igni- tions	Deaths	Igni- tions	Deaths	Igni- tions		Deaths
Alabama.....	1	-	-	-	-	-	1	-	-	-	-	1
Arkansas.....	-	-	-	-	-	-	-	-	-	-	-	1
California.....	1	1	-	-	-	-	-	-	-	-	-	3
Idaho.....	-	1	-	-	-	-	-	-	-	-	-	1
Illinois.....	-	1	9	1	-	-	-	-	-	-	9	1
Indiana.....	1	-	-	1	-	-	-	-	-	-	-	2
Kentucky.....	3	-	-	-	-	-	2	-	-	-	-	3
Missouri.....	-	-	-	1	-	-	-	-	-	-	-	1
New Mexico.....	-	-	-	2	-	-	-	-	-	-	-	2
Pennsylvania....	-	-	-	3	-	-	-	-	-	-	-	3
Virginia.....	-	1	-	-	-	-	-	-	-	-	-	1
Washington.....	-	1	-	-	-	-	-	-	-	-	-	1
Wyoming.....	1	-	-	-	-	-	-	-	-	-	-	1
Total, 1937	7	4	9	10	5	-	3	2	11	21	21	
Total, 1936	16	4	1	3	7	2	3	3	4	23	23	
Total, 1935	7	5	11	14	11	1	-	-	11	26	26	
Total, 1934	10	5	-	3	4	-	-	1	9	18	18	
Total, 1933	12	6	-	9	7	-	2	2	18	27	27	
Total, 1932	8	5	1	8	8	-	3	-	10	21	21	
Total, 1931	12	7	-	5	7	5	-	18	9	24	24	
Total, 1930	7	8	2	9	9	3	3	-	6	24	24	
Total 8 years	79	44	24	61	58	8	12	5	24	63	184	

1/ Includes five metal-mine fires.

2/ Includes 12 metal-mine fires and 2 outcrop fires.

3/ Three of these fires were caused by spontaneous combustion.

4/ Four of these fires were caused by spontaneous combustion.

5/ Includes 5 metal-mine fires and 4 outcrop fires.

It is interesting to note that of the 25 major coal-mine-fire disasters (with a total of 566 fatalities) since 1900, only four (with 29 deaths) have occurred since 1921; that no major coal-mine-fire disasters occurred in the United States from 1926 to 1933, inclusive; and that one occurred in March 1934 with 5 fatalities, one in May 1935 with 6 fatalities, and one in August with 9 fatalities. The occurrence of three major mine fire disasters during the past 3 years (1934, 1935, and 1936), with a total of 20 deaths, together with the fact that none occurred in the preceding 8 years, would indicate that proper precautions are not being taken in the handling of mine fires, especially in protecting workers from poisonous or asphyxiating gases from the fires. This indicates that our coal-mining people, through long immunity from harm to employees through mine fires, either have become negligent or have forgotten much of the knowledge of the hazards of mine fires and of safe and efficient practices and methods of preventing them and of handling them when they do occur.

SUMMARY

The decrease in frequency and severity of explosions in the United States during the past 30 years has been encouraging and indicates that efforts to prevent explosions have been largely successful. The record for the past 4 years has been especially good; however, the fiscal year 1937 shows a considerable increase in the number of fatalities from explosions, compared with the three previous years, and this is a trend that causes considerable concern to those interested in safety in the mines of the United States. The frequency of explosions has not decreased at the same rate as has the severity, and in at least some instances it is only good fortune that more men have not been killed. The decrease in severity of explosions appears to indicate that greater precautions are now being taken to prevent widespread explosions, some of them being rock-dusting and the use of water on the cutter bars of mining machines, as well as the use of more efficient ventilation in holding gas accumulations to a minimum quantity and thus decreasing their "kick".

The years 1918, 1920, 1921, 1931, 1933, 1934, 1935, and 1936 have the best records for major explosions and fires in mines in the United States; during the fiscal year 1937 there were five major explosions and one major fire, which resulted in 56 deaths; in 1936 only two major disasters occurred, in which 17 were killed; and in 1935 there were also two major disasters with 30 deaths. The material decline in the frequency and severity of explosions during the past 6 years is believed to be due primarily to (1) increased vigilance of the various State mine-inspection departments, especially in educational work, and a demand for more rigid adherence to State laws and to safety practices far beyond the strict letter of the law; (2) growing realization of the economic waste of all accidents, including explosions, increasing knowledge of the fact that mines accidents of all kinds can readily be reduced at least 50 percent and possibly more than 75 percent, and more or less general acceptance by the mine operators of responsibility for accident occurrence; and (3) widespread dissemination of safety data by the Bureau of Mines and other organizations devoted largely to the promotion of safety in the mining and allied industries.

Some salient points brought out in the study of mine explosions and fires in the United States by the Safety Division of the Bureau of Mines for the fiscal year ended June 30, 1937, are:

1. Twenty explosions were studied, 16 in bituminous mines and 4 in anthracite mines, compared with 25 in 1936 and a yearly average of 28.2 in the previous 8 fiscal years.

2. Explosions took 62 lives in the fiscal year 1937, compared with 38 in 1936 and an annual average of 110.5 in the previous 8 fiscal years. The 4 explosions in anthracite mines resulted in 5 deaths, while the 16 explosions in bituminous mines resulted in 57 deaths.

3. The 5 major explosions caused 47 deaths, while the 15 minor explosions caused 15 deaths; in six of the explosions no deaths occurred. Two of the major explosions, causing 28 deaths, occurred in the same mine, both being initiated by electricity.

4. Four explosions occurred in open-light mines, compared with 15 in 1936 and a yearly average of 11.2 in the previous 8 fiscal years. Twelve explosions were in closed-light mines, compared with 9 in 1936 and a yearly average of 16 in the previous 8 fiscal years; as in previous years, several explosions in closed-light mines were initiated by open flames (matches used by smokers or to light flame safety lamps, carbide lights used to ignite fuse in blasting, etc.).

5. Twelve explosions, causing 53 deaths, were of electrical origin, compared with 5 explosions and 20 deaths in the previous fiscal year. Explosions of electrical origin averaged 11, with 62 deaths, annually for the previous 8 years; major explosion disasters caused by electricity showed a very definite tendency to increase in the past fiscal year, and this should cause serious concern to the mining people of the United States.

6. Four of the five major explosions that occurred during the year were of electrical origin; the cause of the other, in an anthracite mine, is unknown.

7. Open lights and smoking caused 5 explosions and 3 deaths in 1937, compared with 17 explosions and 10 deaths in 1936 and an average of 11 explosions and 25.6 deaths during the previous 8 fiscal years. Two of these explosions were in anthracite mines and one was in a closed-light bituminous mine where carbide light was used to light shot fuse.

8. One explosion, with no deaths, was attributed to black powder during the past year, compared with 1 explosion and 4 deaths from this cause in 1936 and an average of 4.3 explosions and 18.5 deaths during the previous 8 years. The one explosion caused by black powder was the only purely dust explosion reported. During the past 8 years there has been a gradual decline in both the frequency and severity of explosions caused by explosives, though numerous accidents continue to occur because of explosives fumes, missfires, premature blasts, unsafe storage of explosives, etc.

9. Rock dust was used to some extent in at least six mines in which explosions occurred during the past year; in three of these mines rock dust is credited with being a factor in preventing the spread of the explosion, and it appears possible that as many as 300 lives were saved because of the rock dusting that had been done.

10. All but one of the explosions during the past year are thought to have been initiated by gas, indicating that our mining people have not yet arrived at a satisfactory method of handling explosive gas.

11. The underlying cause of all but one of the explosions that occurred during 1937 was defective ventilation, which was manifest in both open-light and closed-light mines. Neglect of ventilation in closed-light mines is very likely to result in disaster and should not be countenanced in any degree; common sense demands that no mine, gassy or nongassy, coal or metal, should be allowed to operate on an open-light basis.

12. The severity of explosions last year was reduced approximately 25 percent, compared to the average for the preceding 8 years; however, it was a considerable increase over the preceding 3 years. The average number of deaths per explosion last year was 3.1, compared with an average of 4.0 deaths per explosion for the preceding 8 years.

13. The 62 deaths caused by explosions during the fiscal year 1937 occurred in 7 States; 20 of the coal-producing States had no fatalities from this cause, and several of these States have definitely hazardous conditions as to possible occurrence of explosions.

14. During the fiscal year 1937, 21 mine fires (including 5 metal-mine fires) with 11 deaths were reported, compared with an average of 23.7 fires and 7.4 deaths for the preceding 7 years.

15. Several fires with loss of life in small mines, both coal and metal, were caused by ignition of timber surface structures located at the mine opening, and usually the fatalities were due to poisonous gases. The placing of flimsily constructed timber structures at mine portals without taking adequate precautions, by doors or otherwise, against entrance of a surface fire or its gases to the mine is little short of criminal.

16. Entering mines at time of fire or after the fire has apparently been sealed without taking adequate precautions against poisonous or asphyxiating gases cost several lives in both coal and metal mines; and in view of the carelessness with which this type of work is now being done, it appears that unless our mining people take more adequate precautions in these matters the loss of life due to fire in both coal and metal mines is likely to mount.

17. Far too much dependence is being placed on the carbide lamp in both coal and metal mines as a warning agent against deficient atmospheres likely to be found in mines at time of or after mine fires. The carbide light does not give adequate warning under such conditions, and several

lives have been lost relatively recently by depending unduly on it as a warning agent.

13. Mine fires, even relatively small ones, are decidedly dangerous in any mine, but more especially in a coal mine, as they may precipitate explosions; and this is true as to so-called nongassy as well as to gassy mines, some very serious mine explosions with heavy loss of life having occurred in the past few years in foreign coal mines when handling mine fires; and the relatively recent record (especially for the past 3 years) indicates that our coal mining people should increase their carefulness in preventing and handling mine fires.

CONCLUSIONS

This circular was compiled in essentially the same manner as were those of previous years (see Information Circulars 6178, 6419, 6540, 6680, 6761, 6819, 6870, and 6927) and embodies only facts revealed through studies by field employees of the Safety Division of the Bureau of Mines. Although the Bureau of Mines attempts to obtain information concerning every explosion that occurs in the United States, some of the less destructive may not have been brought to its attention early enough to permit investigation. However, the Bureau rarely fails to acquire fairly complete details of mine explosions in which more than one life is lost or in which a considerable amount of property is damaged; therefore, the data in these publications are relatively complete, especially as to explosions causing loss of more than one life.

The data on mine fires are by no means as complete as those on explosions, and there is reason to believe that scores of fires in both coal and metal mines occur annually without the knowledge of the Bureau of Mines or even the State inspection forces. Mine fires occur almost daily in some coal mines, particularly at shot-firing time or when the coal fires spontaneously, and fires of electrical origin or those caused by open lights are not unusual in metal mines.

A study of data available on mine explosions in the United States during the past 9 years reveals an encouraging reduction in the frequency and severity of these disasters. However, the past year showed a sharp increase in severity for which there was no good reason. If the good record of the past 4 years is to be continued, strict vigilance will have to be employed over the factors that contribute to explosions; the most important factors are the maintenance of adequate uninterrupted ventilation and the restriction or possibly the elimination of gas- or dust-igniting agencies.

In the 20-year period preceding 1929, mine explosions and fires took an average toll of about 285 lives annually in the United States; since then the annual average number of fatalities from explosions and fires has been reduced to 114. The fiscal year 1934 established an all-time low record; only 34 fatalities resulted from explosions and fires, compared with 73 fatalities from these causes during the fiscal year 1937. An

analysis of the record for the fiscal years 1934, 1935, 1936, and 1937 demonstrates that explosions can be largely if not wholly prevented and that loss of life from them can be reduced greatly; the occurrence of mine fires with loss of life seems to be increasing somewhat during the past 5 years, and our mining people should by all means "tighten up" in procedure, looking to the prevention of mine fires or to safe handling of them if they should occur. The mining industry should not be satisfied until explosions and fires have been essentially eliminated, and this can be done if mining people utilize readily available equipment, practices, and procedures.

The reduction of fatalities due to gas and dust explosions in bituminous coal mines from an average of 438 per year in the 5-year period 1906-10 to 65 per year in the 5-year period 1931-35, a decrease of 85.2 percent or an average decrease of about 2.8 percent per year, shows what can be done. There is absolutely no reason why the above trend should not continue, with virtually the ultimate elimination of this type of mine accident in bituminous mines within another 5 years; moreover, what the bituminous industry accomplished in prevention of gas and dust explosions should be accomplished as readily in all types of mines, including anthracite properties, and also in metal mines and nonmetallic mineral mines.